

THE HONORABLE COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

Transmitted herewith for filing is the Patent Application of:

Inventor(s): Me Van Le, William E. Wevers

72469 U.S. PTO
08/807232
02/28/97

For: METHOD AND APPARATUS FOR PROVIDING POSITIONAL INFORMATION ON A DISK

Enclosed are:

- ☒ 5 sheets of Formal Drawing(s) including 1-4C figures.
- ☒ An Assignment of the invention to: SAMSUNG ELECTRONICS, LTD.
- ☒ A Declaration and Power of Attorney.
- ☐ A Verified Statement to establish Small Entity Status under 37 CFR 1.9 and 37 CFR 1.27.
- ☐ _____

The Filing Fee has been calculated as shown below:

	(Col. 1)	(Col. 2)	SMALL ENTITY		OTHER THAN A SMALL ENTITY	
For:	No. Filed	No. Extra	RATE	FEE	RATE	FEE
Basic Fee:	-	-	-	\$385.00	-	\$770.00
Total Claims:	20	0	\$11.00	\$0.00	\$22.00	\$0.00
Indep. Claims:	3	0	\$40.00	\$0.00	\$80.00	\$0.00
<input type="checkbox"/> Multiple Dep. Claim(s) Presented			\$130.00	\$0.00	\$260.00	\$0.00
*If the difference in (Col. 1) is less than zero, enter "0" in (Col. 2)			Total:	\$0.00	Total:	\$770.00

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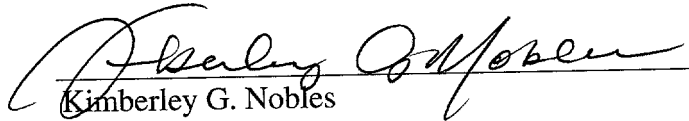
☒ Any extension or petition fees under 37 CFR §1.17.

☒ Any filing fees under 37 CFR §1.16 for presentation of extra claims.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN

Date: February 28, 1997 _____


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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates in general to disk storage systems and more particularly, to a method and apparatus for providing positional information on a disk in a hard drive assembly.

2. Description of the Related Art

Disk drives are magnetic recording devices used for the storage of information. The information is typically recorded on concentric tracks on either surface of one or more magnetic recording disks. To facilitate the storage and retrieval of data in an orderly manner, disks are typically organized in blocks called sectors. These sectors are located on the disk by a set of unique specifiers called cylinder (or track), head (or side) and sector number. The disks are rotatably mounted to a spin motor and information is accessed by means of read/write heads that are mounted to actuator arms which are rotated by a voice coil motor. The voice coil motor is excited with a current to rotate the actuator and move the heads.

The movement of the actuator is controlled by a servo system, utilizing servo information recorded on one or more of the magnetic recording disks. By reading this servo information, the actual radial positions of the heads can be determined, and after comparison with the desired head radial positions, control signals can be sent to move the actuator accordingly. Servo information

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is typically stored on a disk in one of two ways. In the first, a dedicated servo system, a set of several tracks on the disk or the entire disk surface, is reserved exclusively for storing information associated with the characteristic of the particular drive. Such information includes servo parameters and read/write channel parameters. A servo head reads this information to provide a continuous signal indicating the position of the servo head with respect to the servo disk. In the second type of servo system, the embedded servo system, sectors of servo information are interspersed with sectors of data on each disk surface. As a read head follows the data track around, it regularly reads a fresh sample of servo information from each servo sector with which to control its position.

Figure 1 illustrates a typical sector on a disk of a hard disk drive. As shown, a typical sector 10 has a preamble field 20 which includes automatic gain control (AGC) information and synchronization information, a servo address mark 22 which signifies the beginning of a sector, an index field 24 which indicates the beginning of the first sector of the track, an identification field 26 which includes identification bits, a head identification field 28 for identification of head location, a gray code field 30 that identifies the particular cylinder (tracks) of the sector, a servo bit field 32 which includes a number of servo bits A, B, C, D, and a data field 34 which contains the data. The servo bits A, B, C and D are used to maintain the read/write head on the centerline CL of a

corresponding track. The identification field 26 typically includes an index bit and 7 bits of angular position information; the head identification field 28 typically includes 3 bits of data for identifying the head (or side) position of the disk pack and the gray code field 30 typically includes 13 bits of data for providing track identification. In conventional disk drives, absolute positional information is stored in graycode in the gray code field 30 of a particular sector 10. Due to power consumption, cost and throughput concerns, reduction of media space used in providing the servo information is highly desirable. However, most of the segments of the sector 10 are head and/or media dependent and reduction of these segments is difficult.

Accordingly, there is a need in the technology for a method and apparatus for providing servo information on a disk in a hard drive assembly while reducing the media space required for the provision of such information.

BRIEF SUMMARY OF THE INVENTION

5 The present invention is a method and apparatus for providing positional information of a disk. The disk has at least one side with a plurality of tracks, each having a first burst in a first servo field and a second burst in a second servo field. The first burst provides a first portion of track position information while the second burst provides a second portion of track position information. When combined, the first and second portions provide a position of a corresponding track. Each track further includes a third and a fourth
10 burst that provides a first portion and a second portion of disk side position information. When combined, the first and second portions of disk side position information provide the disk side position of the disk. Each track also includes a burst that provides the quadrant position of the disk. In one embodiment, the first and second bursts
15 are located on consecutive sectors, and each track includes a servo sector sequence burst with a sector sequence number that identifies the sequence position of the consecutive sectors. The first portion, the second portion and their corresponding sector sequence number in combination provide a position of a corresponding track.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a typical data sector of a disk in a disk drive assembly of the prior art.

Figure 2 is a top view of a hard disk drive assembly which
5 utilizes the apparatus and method of the present invention.

Figure 3A illustrates exemplary sectors on heads H0 - H3 (sides 1-4) of the disk pack 100 of Figure 2.

Figure 3B illustrates an enlarged view of a typical sector of on one side of the disk pack 100 of Figure 3A as provided in accordance
10 with the teachings of the present invention.

Figure 4A illustrates a plurality of consecutive sectors on one side of the disk pack 100, in accordance with the teachings of the present invention.

Figure 4B illustrates four bits of head position information as
15 provided by the SDAT fields of sectors 2 and 3 in Figure 4A respectively.

Figure 4C illustrates the thirteen bits of track position information, of which bits 8-13 are provided by the SDAT fields of sectors 4-6 of Figure 4A and of which bits 0-7 are provided by the
20 Graycode field from each sector of Figure 4A.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is an apparatus and method for Referring to the drawings more particularly by reference numbers, Figure 2 illustrates a hard disk drive 50 which utilizes the method of the present invention. The disk drive 50 includes a disk pack 100 with a plurality of disks 102 that are collectively rotated by a spin motor 104. The spin motor 104 is mounted to a base plate 106. Also mounted to the base plate 106 is an actuator arm assembly 108. The actuator arm assembly 108 includes a number of read/write (R/W) heads 110a-d mounted to corresponding flexure arms 112. The flexure arms 112 are attached to an actuator arm 114 that can rotate about a bearing assembly 116. The assembly 108 also contains a voice coil motor 118 which moves the heads 110a-d collectively relative to the disks 102. There is typically a single head 110a, 110b, 110c, or 110d for disk head side H0, H1, H2 or H3 (not shown), respectively, of the disk pack 100. The spin motor 104, voice coil motor 118 and the R/W heads 110a-d are coupled to a number of electronic circuits 120 mounted to a printed circuit board 122. The electronic circuits 120 typically include a read channel chip, a microprocessor-based controller and a random access memory (RAM) device.

As shown in Figure 3A, data is typically stored within sectors 140₁, 140₂ and 140₃ of radially concentric tracks located across any one of the disk heads H0-H3 of the disk pack 100. For discussion purposes, any one of the sectors 140₁, 140₂ and 140₃

will be referred to as sector 140. In one embodiment, as shown in Figure 3B, each sector 140 has a preamble field 150 which includes automatic gain control (AGC) information and synchronization information, an address mark 152 which signifies the beginning of the sector 140, an index field 154 which indicates the beginning of the first sector of the track, a servo sector sequence number (SSN) field 156 that identifies the sector sequence location number of sector 140 as identified among a plurality of consecutive sectors, a servo multiplex data (SDAT) field 158 that provides the higher order bit information related to positional information of the particular cylinder (track) of the sector 140, a gray code field 160 that provides the lower order bit information related to positional information of the particular cylinder (track) of the sector 140, a synchronization field 162, a servo bit field 164 which includes a number of servo bits A, B, C, D, and a data field 166 which contains the data. For present purposes, fields 150-164 will be referred to as the servo field while field 166 will be referred to as the data field. The electronic circuits 120 (see Figure 2) utilize the servo bits A, B, C and D to maintain the heads 110a-d on the centerline CL of a corresponding track. The heads 110a-d can magnetize and sense the magnetic field of the disk heads H0-H3 to as to provide the information located on the above-described fields 150-166.

In one embodiment, positional information is provided by reading the SSN field 156, the SDAT field 158 and the graycode field 160 of six consecutive bursts of servo data. Table 1

illustrates an example of positional information that is provided in the SSN field 156, the SDAT field 158 and the graycode field 160, and the interrelationship between the fields. Together, the information located in the SSN field 156, the SDAT field 158 and the graycode field 160 provide a matrix of positional information for identifying the quadrant, the head and track position of the disk pack 100.

As shown in Table 1, there are 72 servo sectors on an exemplary head, head 4 (H3) of the disk pack 100, each labeled from 0-71. The 72 servo sectors are divided into groups each having six consecutive sectors. Each of the six consecutive sectors can be identified by an SSN of 0-7, since a minimum of 3 bits are required, as provided in the SSN field 156 of each sector 140 (see Figure 3B). As discussed earlier, the (SDAT) field 158 provides the higher order bit information related to positional information of the particular cylinder (track) of the sector 140, while the gray code field 160 provides the lower order bit information related to positional information of the particular cylinder (track) of the sector 140.

In one embodiment, index information is provided in field 156₀ of sector 0 as 7 (binary 111). In one alternate embodiment, index information is provided in both sectors 0 and 1. In this case, the index information is provided in SSN field 156₀ as 7 (binary 111) and in SSN field 156₁, as 6 (binary 110).

Example of data in servo pattern at Cylinder 24CDH, Heads 4.
 Binary CDH = Graycode CDH
 Binary 24H = Graycode 26H

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positional information of the particular cylinder (track) of a disk in the disk pack 100. For example, the combination of SSN = 3 and SDAT = 10 or 01 provides the position information of bits 13 and 12, where the bit positions are identified from 0 - 13 (the 14th and 13th bits among 14 bits) of graycode information required to completely identify the cylinder or track on a disk.

Similarly, the combination of SSN = 4 and SDAT = 01 or 10 provides position information of bits 11 and 10 (the 12th and 11th bits among 14 bits) of the graycode information required to completely identify the cylinder, while the combination of SSN = 5 and SDAT = 10 or 01 provides positional information for bits 9 and 8 (the 10th and 9th bits among 14 bits) of graycode information required to completely identify the cylinder. The remaining 8 bits of graycode information is located in the graycode field 160 located in each sector 140.

Figure 4A illustrates an example of how the present invention may be implemented utilizing six consecutive sectors on a typical track. The six sectors, SECTORS 0-5, each has an SSN field 156₀ - 156₅, an SDAT field 158₀ - 158₅ and a graycode field 160₀ - 160₅. Each SSN field 156₀ - 156₅ provides 3 bits of information related to the sector sequence position of each sector SECTORS 0-5 among the 6 sectors, while each SDAT field 158₀ - 158₅ provides 2 bits of information which provides any of the following information when used in combination with the SSN number: (1) identifies the quadrant position of a disk in the disk pack 100; (2) identifies the head (or side) of the disk pack 100 or (3) provides 2 of six

upper bits of information related to the track position information; and each graycode field 160₀ - 160₅ provides the 8 lower bits of information related to track position information.

As discussed earlier, the combination of SSN = 0 and an SDAT number identifies the quadrant position on a disk in the disk pack 100. In addition, the combination of SSN = 1 or SSN = 2 with an SDAT number identifies a particular position as the head (or side position) of the disk pack 100. Finally, the combination of SSN = 3, 4 or 5 and an SDAT number provides the higher order bit information related to positional information of the particular cylinder (track) of a disk in the disk pack 100.

Figure 4B illustrates the 4 bits of information that may be obtained from two of the six sectors, SECTORS 1 and 2, which together identifies head (or side) position of a disk pack 100. As shown, when the SSN field 156 preceding an SDAT field 158 indicates that the SSN is 1 (binary 001), the following SDAT field 158 will provide the upper 2 bits of head positional information. When the SSN field 156 preceding an SDAT field 158 indicates that the SSN is 2 (binary 010), the following SDAT field 158 will provide the lower 2 bits of head positional information. After reading the SSN fields 156₁ and 156₂ of the sectors SECTORS 1 and 2, one will obtain the head position information of a particular location of the disk pack 100.

Figure 4C illustrates the 14 bits of information that may be obtained from three of six sectors, SECTORS 3 - 5, which together

identifies the track (or cylinder) position of a disk pack 100.

As shown, each graycode field 160₀ - 160₅ provides the 8 lower bits of information related to track position information. When one of the R/W heads 100a-d is reading from a track within a particular

band of tracks, where there are 256 tracks in one band, the

information from the 8 lower bits is sufficient to identify the

position of the head. However, when any of the R/W heads 100a-d

is moving from one band to another, additional information is

required to identify its location. As shown, when the SSN field

156 preceding an SDAT field 158 indicates that the SSN is 3

(binary 011), the following SDAT field will provide the two

uppermost bits (bits 13 and 12) of the 14 bits of data required to

provide track position. When the SSN field 158 indicates that the

SSN is 4 (binary 100), the following SDAT field 158 will provide

the following two uppermost bits (bits 11 and 10) of the 14 bits

of data required to provide track information. Finally, when the

SSN field 156 indicates that the SSN is 5 (binary 101), the

following SDAT field 158 will provide the last of the uppermost

bits (bits 9 and 8) of the 14 bits of data required to provide

track position. Thus, by scanning the SSN field 156, the SDAT

field 158 and the graycode field 160 of at least 6 consecutive

sectors as provided by the present invention, complete positional

information of a particular location on the disk pack 100 may be

obtained.

Through the implementation of the technique of the present invention, servo information on a disk in a hard drive assembly may be

CLAIMS

What is claimed:

1 1. A disk for a hard disk drive, comprising:

2 a disk having at least one side with a plurality of
3 tracks, each of said tracks having a first burst in a first servo
4 field and a second burst in a second servo field, said first burst
5 providing a first portion of track position information and said
6 second burst providing a second portion of track position
7 information, said first and second portions in combination
8 providing a position of a corresponding track.

1 2. The disk as recited in claim 1, wherein said first burst
2 and said second bursts are located on consecutive sectors of each
3 track.

1 3. The disk as recited in claim 2, wherein each track
2 further comprises a third burst that provides a sector sequence
3 number that identifies the sequence position of each of said
4 consecutive sectors.

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1 8. The disk as recited in claim 1, wherein said disk has a
2 second side with a second plurality of tracks, wherein each track
3 on each side of said disk includes said first burst and said
4 second burst.

1 9. The disk as recited in claim 2, wherein each track on
2 each side of said disk further comprises a third burst and a
3 fourth burst, said third and fourth bursts providing a first
4 portion and a second portion of disk side position information
5 respectively, said first and second portions of disk side position
6 information in combination providing a position of a side of the
7 disk.

1 10. A hard disk drive, comprising:

2 a housing;

3 a spin motor mounted to said housing;

4 an actuator arm mounted to said spin motor;

5 a disk attached to said spin motor, said disk having at
6 least one side with a plurality of tracks, each of said tracks
7 having a first burst in a first field and a second burst in a

8 second field, said first burst providing a first portion of track
9 position information and said second burst providing a second
10 portion of track position information, said first and second
11 portions in combination providing a position of a corresponding
12 track; and

13 a read/write head mounted to said actuator arm for
14 reading said at least one side of said disk.

1 11. The hard disk drive as recited in claim 1, wherein said
2 first burst and said second bursts are located on consecutive
3 sectors of each track.

1 12. The hard disk drive as recited in claim 11, wherein each
2 track further comprises a third burst that provides a sector
3 sequence number that identifies the sequence position of each of
4 said consecutive sectors.

1 13. The hard disk drive as recited in claim 10, wherein each
2 track further comprises a third burst that provides a third
3 portion of track position information, said first, second and
4 third portions in combination providing a position of a
5 corresponding track.

10 wherein said hard disk drive further comprises a second
11 read/write head mounted to said actuator arm for reading said
12 second side of said disk.

1 17. A method for providing servo information on a disk in a
2 hard disk drive, comprising the steps of:

3 a) providing a disk having a at least one side with a
4 plurality of tracks, each of said tracks having a first in a first
5 servo field and a second burst in a second servo field, said first
6 burst providing a first portion of track position information and
7 said second burst providing a second portion of track position
8 information;

9 b) reading said first burst;

10 c) reading said second burst; and

11 d) combining said first and said second portions to
12 provide a position of a corresponding track.

1 18. The method as recited in claim 17, wherein step a) further
2 comprises the step of: providing a third burst that provides a sector
3 sequence number that identifies the sequence position of each of said
4 consecutive sectors;

5 wherein the method further comprises the steps of: reading
6 said third burst, after step c); and

7 the step of: e) combining said first, and second portions
8 and their corresponding sequence numbers to provide a position of a
9 corresponding track.

1 19. The method as recited in claim 17, wherein step a)
2 further comprises the step of providing a third burst that
3 provides a quadrant position of said disk.

1 20. The method as recited in claim 17, wherein in step a),
2 said disk has a second side with a second plurality of tracks,
3 wherein each track on each side of said disk includes said first
4 burst and said second burst; and wherein each track on each side
5 of said disk further comprises a third burst and a fourth burst,
6 said third and fourth bursts providing a first portion and a
7 second portion of disk side position information respectively;
8 wherein said method further comprises the step of:

9 e) reading said first and second portions of disk side
10 position information; and

11 f) combining said first and second portions to provide
12 a position of a side of the disk.

10

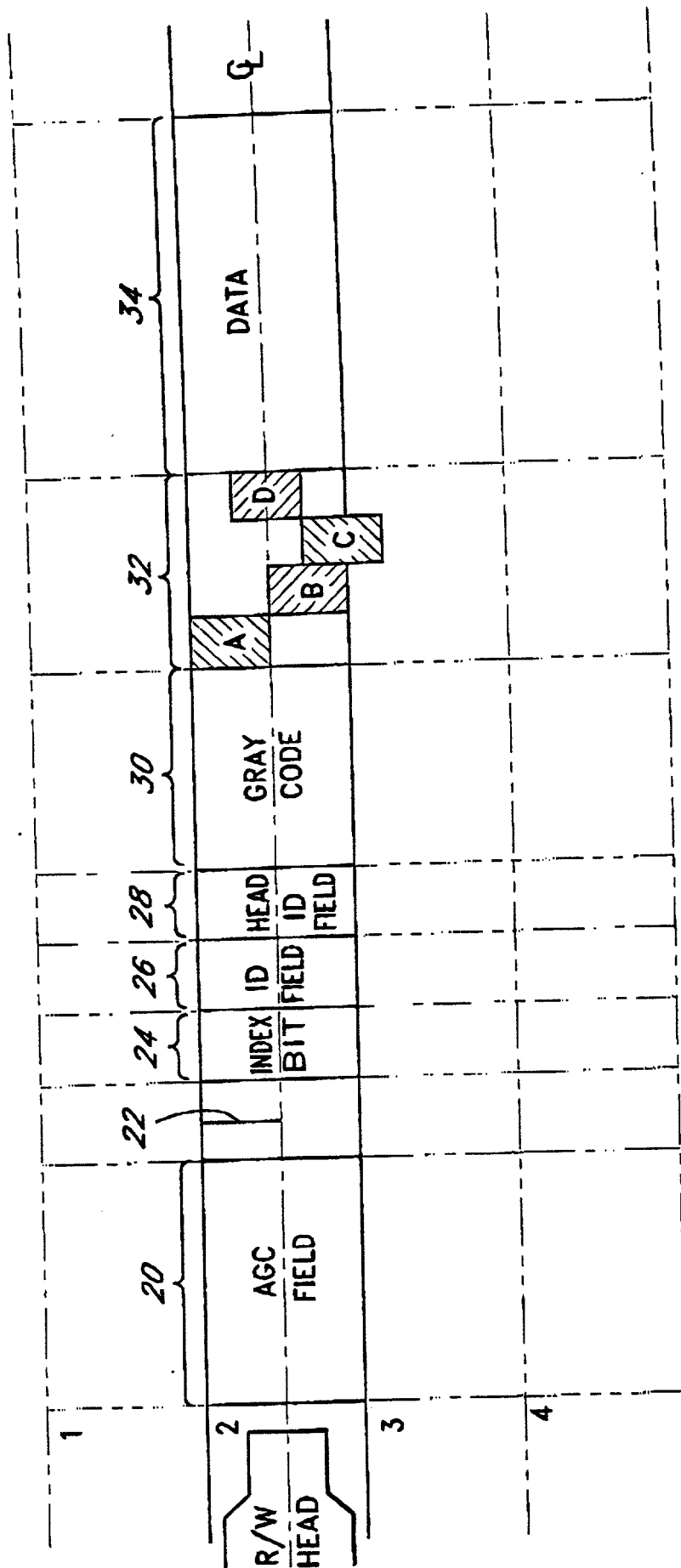
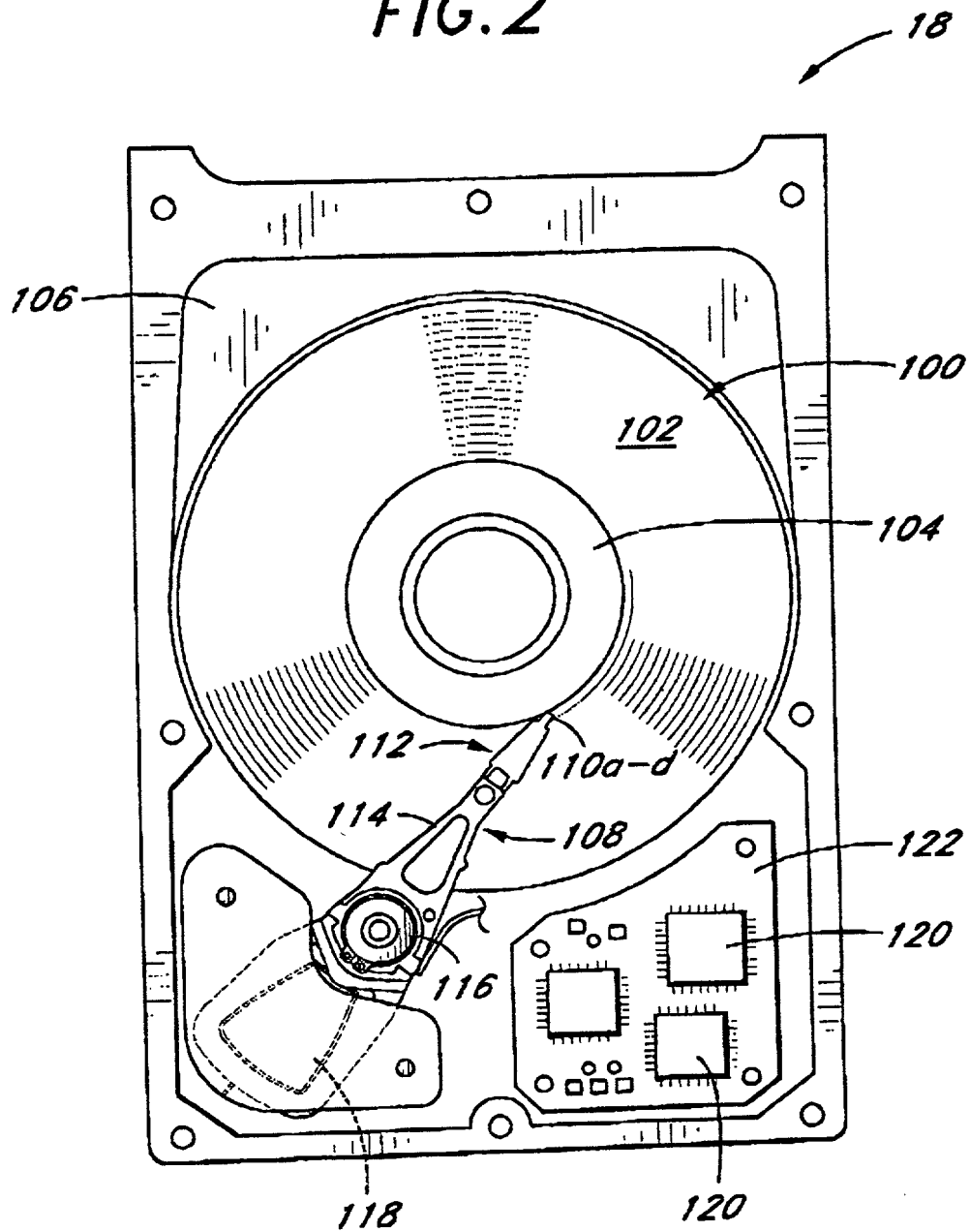


FIG. 2



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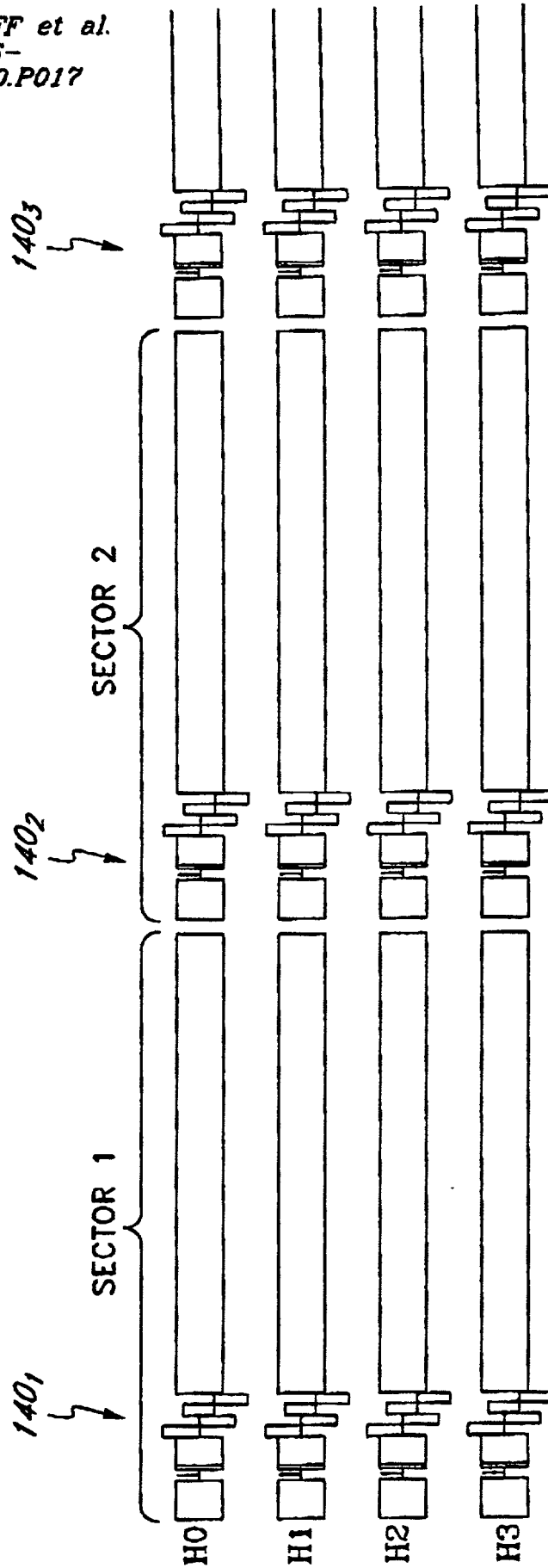
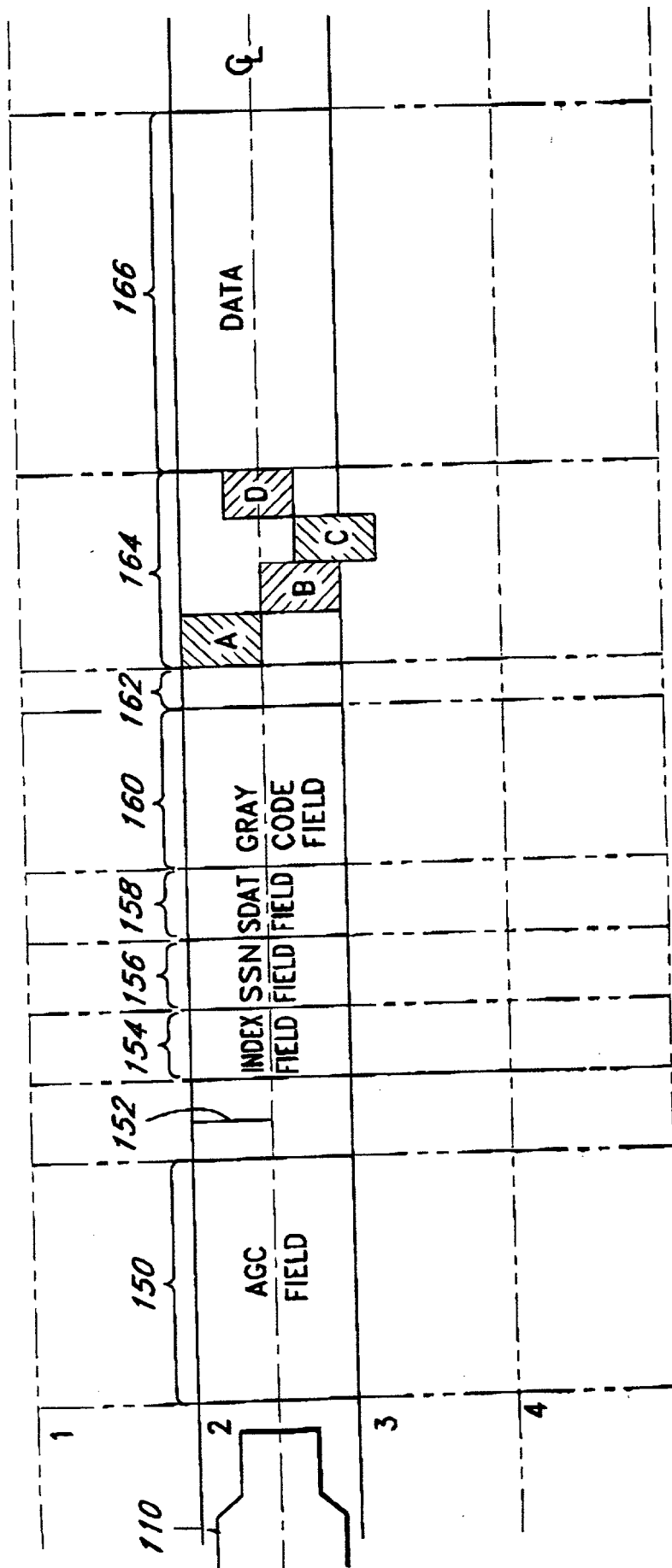
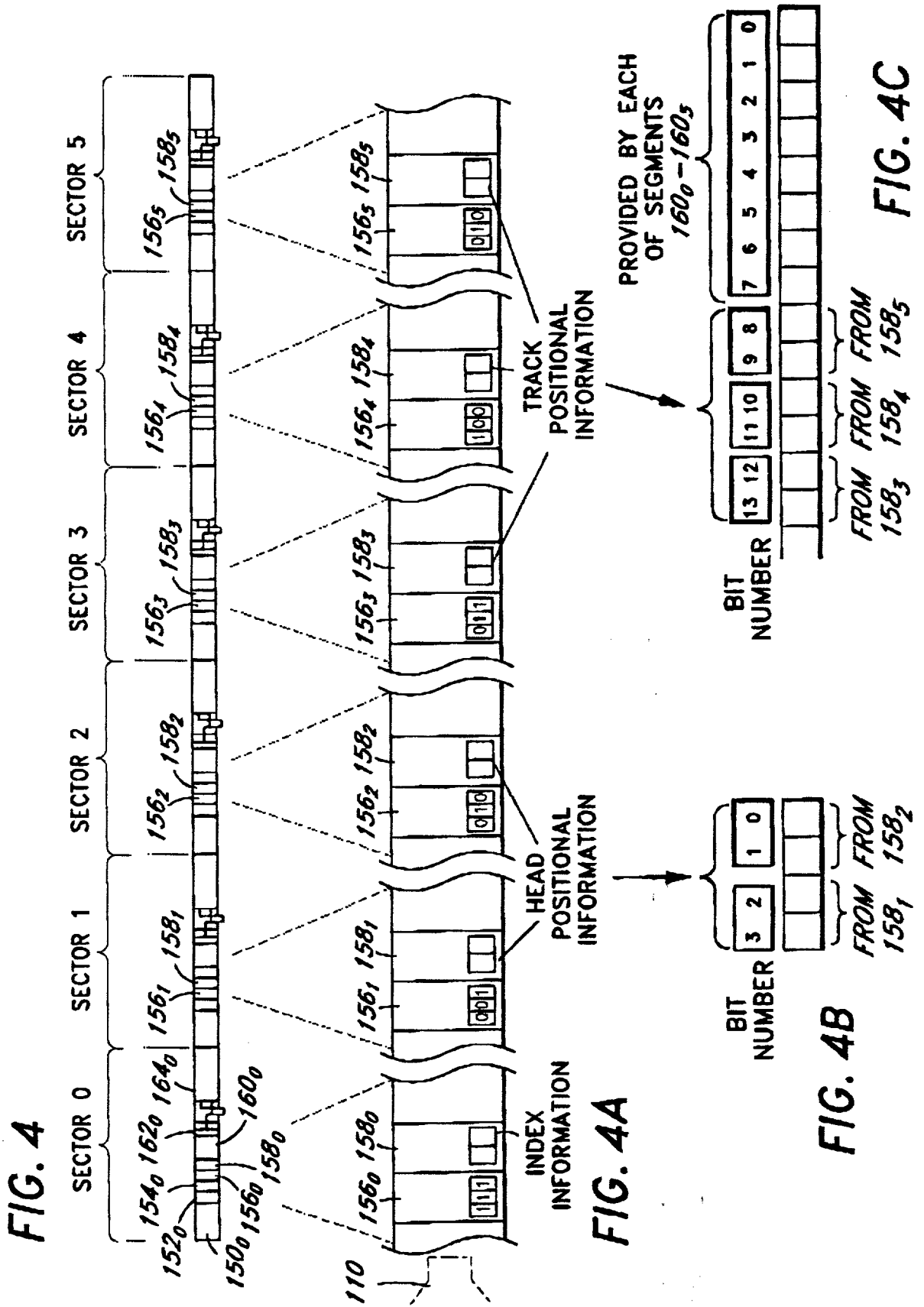


FIG. 3A

140





date of this application:

(Application Serial No.)	(Filing Date)	(Status -- patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status -- patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status -- patented, pending, abandoned)

I hereby appoint BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN, a firm including:
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Jordan Michael Becker, Reg. No. 39,602; Bradley J. Bereznak, Reg. No. 33,474;
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Edwin H. Taylor, Reg. No. 25,129; Lester J. Vincent, Reg. No. 31,460;
John Patrick Ward, Reg. No. 40,216; Ben J. Yorks, Reg. No. 33,609; and
Norman Zafman, Reg. No. 26,250; my attorneys; and Gary B. Goates, Reg. No. 35,159;
Michael Anthony DeSanctis, Reg. No. 39,957; Charles E. Shemwell, Reg. No. 40,171;
Edwin A. Sloane, Reg. No. 34,728; and Judith A. Szepesi, Reg. No. 39,393; my patent
agents, with offices located at 12400 Wilshire Boulevard, 7th Floor, Los Angeles, California
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this application and to transact all business in the Patent and Trademark Office connected herewith.

I hereby declare that all statements made herein of my own knowledge are true and that all
statements made on information and belief are believed to be true; and further that these statements
were made with the knowledge that willful false statements and the like so made are punishable by
fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that
such willful false statements may jeopardize the validity of the application or any patent issued
thereon.

Full Name of First Inventor ME VAN LE

Inventor's Signature Me Van Le Date 2/24/97

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(City, State) (Country)

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MILPITAS, CA 95035

Post Office Address 2967 DENSMORE DRIVE
SAN JOSE, CA 95148

Variable	Mean		SD		t		p	
	Control	Case	Control	Case	Control	Case	Control	Case
Age	34.5	34.5	10.5	10.5	0.0	0.0	0.999	0.999
Gender	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Education	12.5	12.5	1.0	1.0	0.0	0.0	0.999	0.999
Marital status	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Occupation	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Income	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Religion	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Health status	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Family size	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Urban/rural	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Marriage duration	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's sex	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's age	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's education	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's occupation	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's income	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's health status	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's family size	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's urban/rural	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's marriage duration	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's sex	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's age	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's education	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's occupation	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's income	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's health status	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's family size	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's urban/rural	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's marriage duration	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's child's sex	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's child's age	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's child's education	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's child's occupation	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's child's income	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's child's health status	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's child's family size	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's child's urban/rural	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's child's marriage duration	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's child's child's sex	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's child's child's age	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's child's child's education	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's child's child's occupation	1.0	1.0	0.0	0.0	0.0	0.0	0.999	0.999
Child's child's								